Efficiency of the Horizontal Hodoscope

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Abstract

The efficiency of both arms of the upgraded Horizontal Hodoscope and its constituent scintillating slabs from data taken in 2008, 2009 and 2010 was calculated. The results are presented in this note.

1 Introduction

The Horizontal Hodoscope (HH) at the experiment DIRAC is used (among with Vertical Hodoscope and Drift Chambers [1]) for particle tracking and is included in the first level of trigger system (T1). The output determines particle pair coplanarity and picks up pairs with relative distance up to 75 mm in vertical direction. Each arm of HH consists of 16 scintillating slabs with 150 cm length and 2.5 cm width (replacing original 130 cm long slabs) [4].

For good knowledge of characteristics of HH function, it is necessary to know its efficiency of detection. Besides total efficiency of each arm, an useful information is the efficiency of each scintillating slab.

After the calibration runs in 2007, the efficiency was not evaluated on a regular basis. Therefore, the runs taken in years 2008, 2009 and 2010 provides data from which we can calculate desired efficiencies.

2 Method

Because the triggering system requires a hit in HH to process the event [3], regular runs can't be used for calculations (the efficiency would be 100%). To avoid the influence of T1 trigger, in which the hodoscopes are included, special runs had to be scheduled each year with the condition of HH hit disabled. The numbers of these runs are 8532, 9775 and 10324.

The data were processed with modified version of Ariane software. The output of this programme was a 2D histogram – basically a map of hits in an arm. For rough calculation of total efficiency of an arm simply the number of hits in HH was divided by number of events.

Each histogram of hits (each year, both arms) was then projected to the x axis and in ROOT analysis programme [2] divided by whole histogram of all events. The result is a histogram of inefficiency, see fig. 2 and 3.

The gaps between slabs are clearly notable, they massively contribute to the total inefficiency. To suppress their insensitivity and the edge effect, the method of determination of slab inefficiency assumes that the inefficiency is invariable in the middle of a slab. In ROOT, we simply localize the center of a gap, cut 0.5 cm at each side of a slab and fit the inside 1.5cm area with polynomial function of 0th order (constant function), as shown in figure 1.

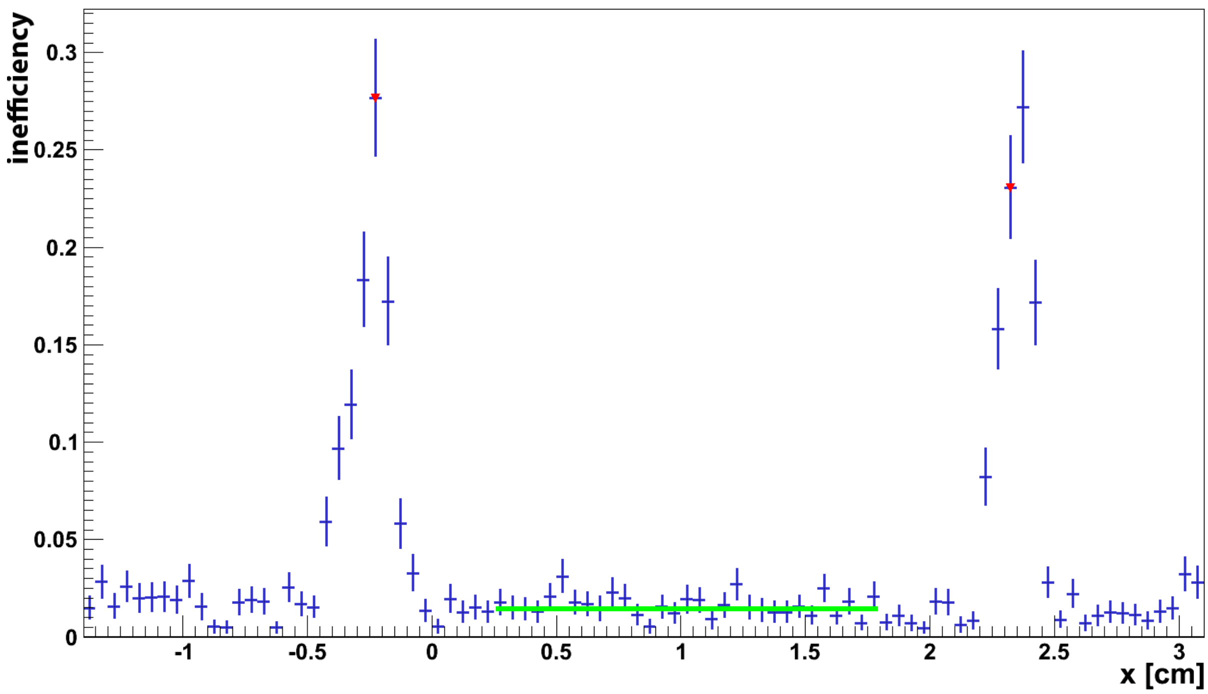

Figure 1: The detail of inefficiency histogram for the left arm of HH in 2008 with marked peaks and fitted constant function

The histograms show expected decline of efficiency. From these results, it can't be decided, on which side of scintillating slab the problem lies. Therefore, the determination of longitudinal efficiency of each slab was promoted.

For this purpose, 2D histograms from 2010 were taken again and sliced, using the coordinates from fits in single slabs. These "ribbons", representing the active volume of a slab, were then split into 14 sections (bins) and projected on the y axis. Projected histograms of hits were divided by histograms of all events. Resultant histograms are shown in the next section.

3 Results

The total efficiencies of right (R) and left (L) arms in years 2008, 2009 and 2010 are:

$$\eta_8^R = 96.08 \pm 0.03~\%, \quad \eta_9^R = 95.90 \pm 0.03~\%, \quad \eta_{10}^R = 91.21 \pm 0.02~\%, \tag{1}$$

$$\eta_8^L = 96.39 \pm 0.02~\%, \quad \eta_9^L = 95.63 \pm 0.03~\%, \quad \eta_{10}^L = 94.31 \pm 0.03~\%. \tag{2}$$

The efficiencies of single slabs through years 2008–2010 are shown in figures 2, 3 and summarized in tables 1 and 2. The average slab efficiency in 2010 was 96.16 ± 0.15 % for the left and 92.23 ± 0.22 % for the right arm. The comparison with "total" results (1), (2) reveals the share of gap insensitiveness on the total efficiency.

The longitudinal efficiencies of slabs in year 2010 are presented on histograms in figures 4, 5 for the right arm and 6, 7 for the left arm of the Horizontal Hodoscope. The major decrease of efficiency (≈ 90 %) was detected in slabs 9, 10, 12 and 14 of right arm and 3 and 14 of left arm. The presented histograms of longitudinal efficiency show, that the troubles are probably located at the edges of scintillating slabs.

4 Conclusion

The efficiency of the Horizontal Hodoscope in years 2008, 2009 and 2010 dropped deeper in right then in left arm (see eq. (2), (1)). For comparison, the efficiency of the first HH, calculated from data taken in years 2001 through 2003, declined from 95.4 to 92.2 % in right and 94.3 to 87.4 % in left arm.

The decline of Horizontal Hodoscope performance might be caused by poor connection between slab, optical contact, lightguide and photomultiplier or by the malfunction of photomultiplier itself. That could be the result of heavy radiation damage or some other mechanical defect. Therefore, precise calibration has to be performed and its effect should be verified by calculation on another special run.

Slab	Right arm 2008 Efficiency [%]	Right arm 2009 Efficiency [%]	Right arm 2010 Efficiency [%]
1	98,42 ± 0,21	97,02 ± 0,21	94,71 ± 0,27
2	98,10 ± 0,16	97,20 ± 0,15	95,29 ± 0,17
3	97,73 ± 0,16	96,74 ± 0,14	94,67 ± 0,17
4	97,25 ± 0,17	96,79 ± 0,14	92,52 ± 0,19
5	97,29 ± 0,17	96,78 ± 0,13	94,07 ± 0,17
6	97,25 ± 0,16	97,17 ± 0,13	95,53 ± 0,14
7	97,64 ± 0,15	97,22 ± 0,12	92,59 ± 0,19
8	97,42 ± 0,15	96,85 ± 0,13	93,20 ± 0,18
9	97,77 ± 0,14	96,48 ± 0,13	88,38 ± 0,23
10	97,67 ± 0,15	96,56 ± 0,13	87,11 ± 0,24
11	97,46 ± 0,15	97,32 ± 0,12	94,75 ± 0,15
12	97,58 ± 0,15	97,04 ± 0,13	90,93 ± 0,20
13	97,93 ± 0,14	96,96 ± 0,13	92,11 ± 0,19
14	97,75 ± 0,16	96,84 ± 0,14	88,52 ± 0,25
15	96,99 ± 0,21	97,16 ± 0,16	91,71 ± 0,24
16	97,47 ± 0,34	97,51 ± 0,26	90,11 ± 0,48

Table 1: Efficiency of single slabs of the right arm of HH in years 2008, 2009 and 2010

Slab	Left arm 2008 Efficiency [%]	Left arm 2009 Efficiency [%]	Left arm 2010 Efficiency [%]
1	99,07 ± 0,17	98,80 ± 0,14	98,25 ± 0,20
2	98,74 ± 0,13	97,54 ± 0,14	96,72 ± 0,15
3	98,66 ± 0,12	97,54 ± 0,13	88,68 ± 0,25
4	97,73 ± 0,15	97,28 ± 0,13	96,06 ± 0,14
5	98,51 ± 0,12	97,72 ± 0,12	96,99 ± 0,12
6	98,45 ± 0,12	97,60 ± 0,12	97,05 ± 0,12
7	98,64 ± 0,11	97,85 ± 0,11	97,07 ± 0,12
8	98,77 ± 0,11	98,11 ± 0,10	97,35 ± 0,11
9	98,58 ± 0,11	97,68 ± 0,11	96,77 ± 0,12
10	98,22 ± 0,12	96,88 ± 0,13	96,08 ± 0,13
11	98,34 ± 0,12	97,32 ± 0,12	96,66 ± 0,12
12	98,42 ± 0,12	97,27 ± 0,13	96,63 ± 0,13
13	98,47 ± 0,12	97,59 ± 0,12	96,51 ± 0,13
14	95,40 ± 0,22	94,71 ± 0,19	93,39 ± 0,19
15	98,81 ± 0,12	97,97 ± 0,13	96,89 ± 0,14
16	98,91 ± 0,17	98,14 ± 0,18	97,46 ± 0,21

Table 2: Efficiency of single slabs of the left arm of HH in years 2008, 2009 and 2010

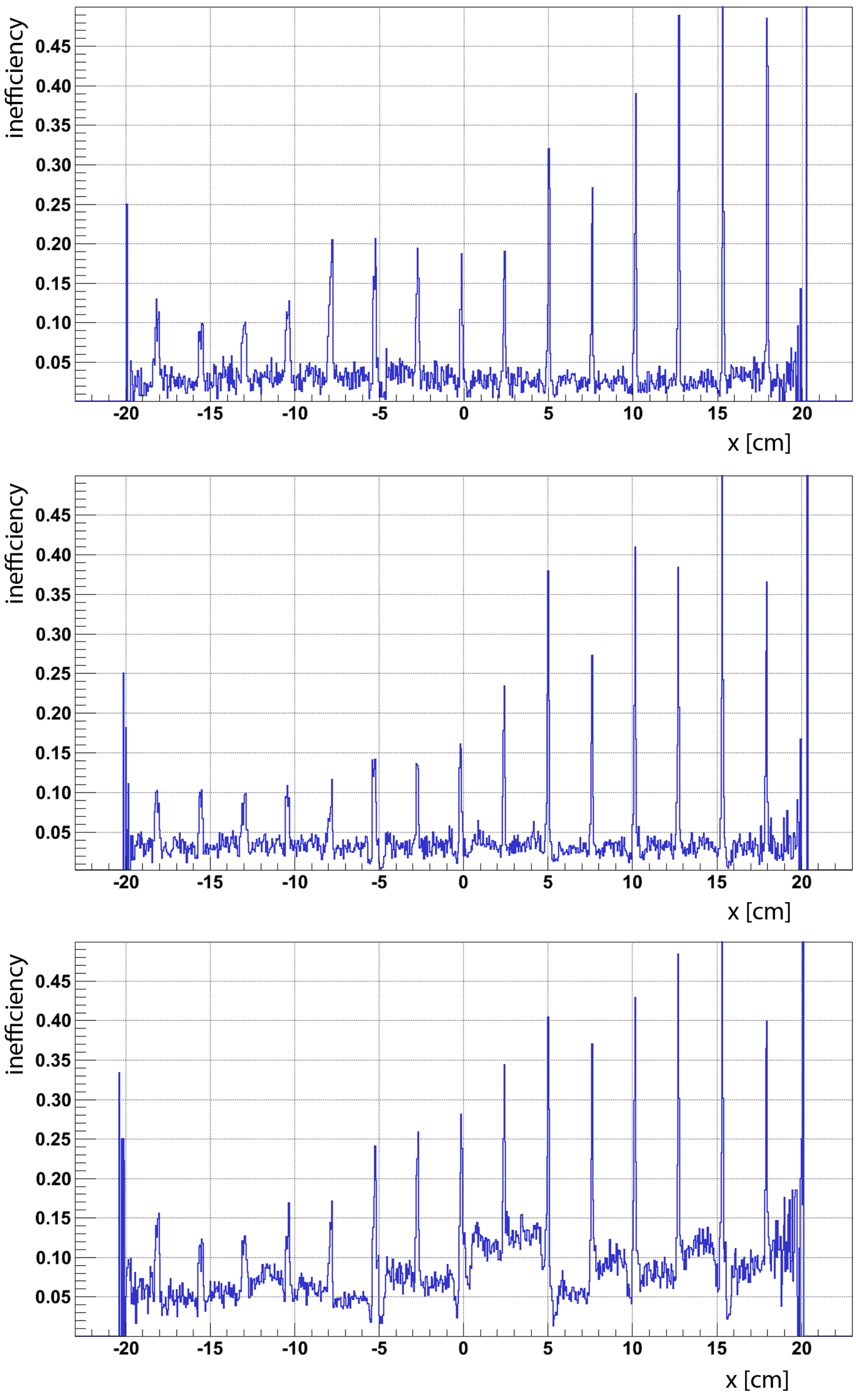

Figure 2: Right arm inefficiency in years 2008 (top), 2009 (middle) and 2010 (bottom)

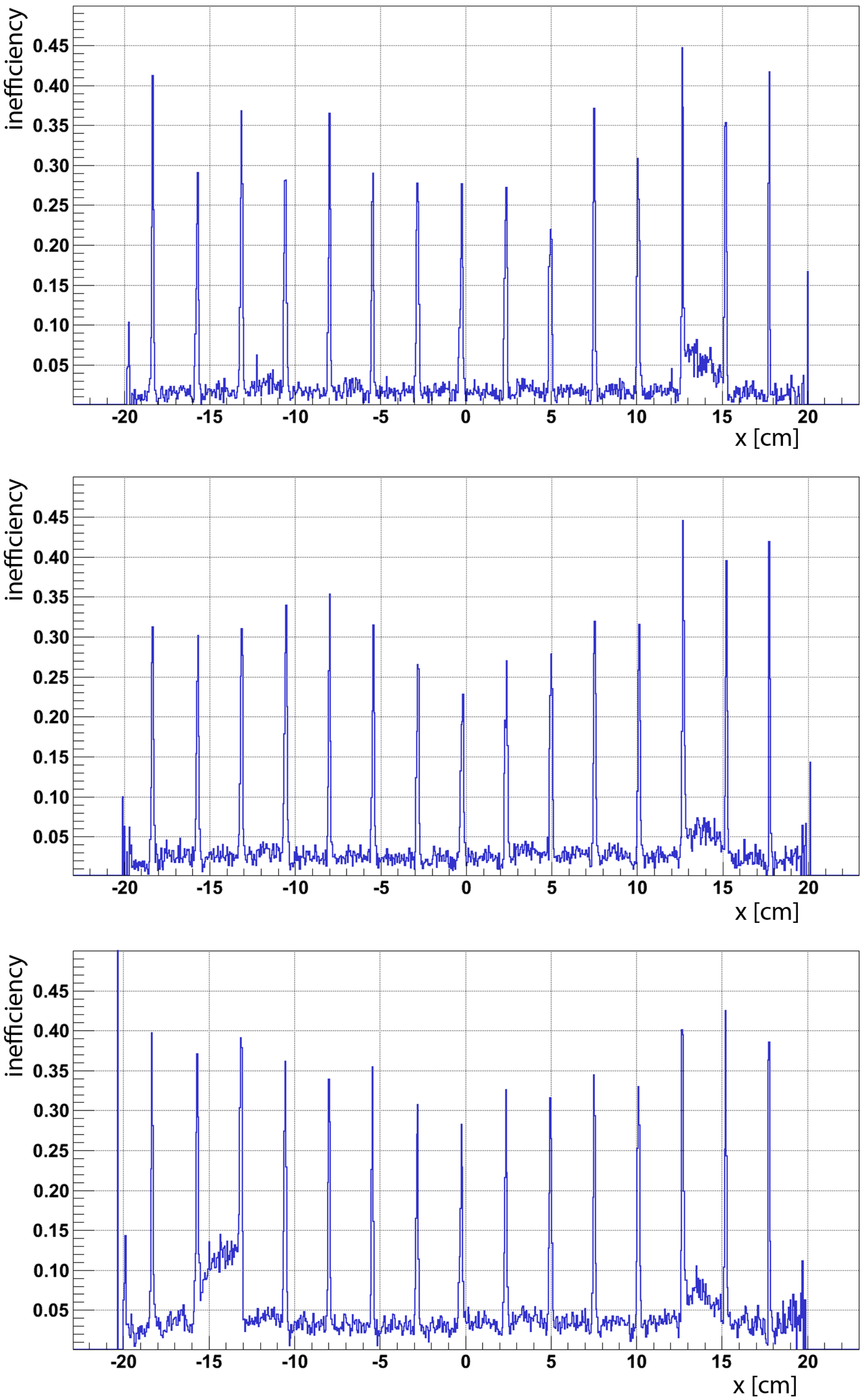

Figure 3: Left arm inefficiency in years 2008 (top), 2009 (middle) and 2010 (bottom)

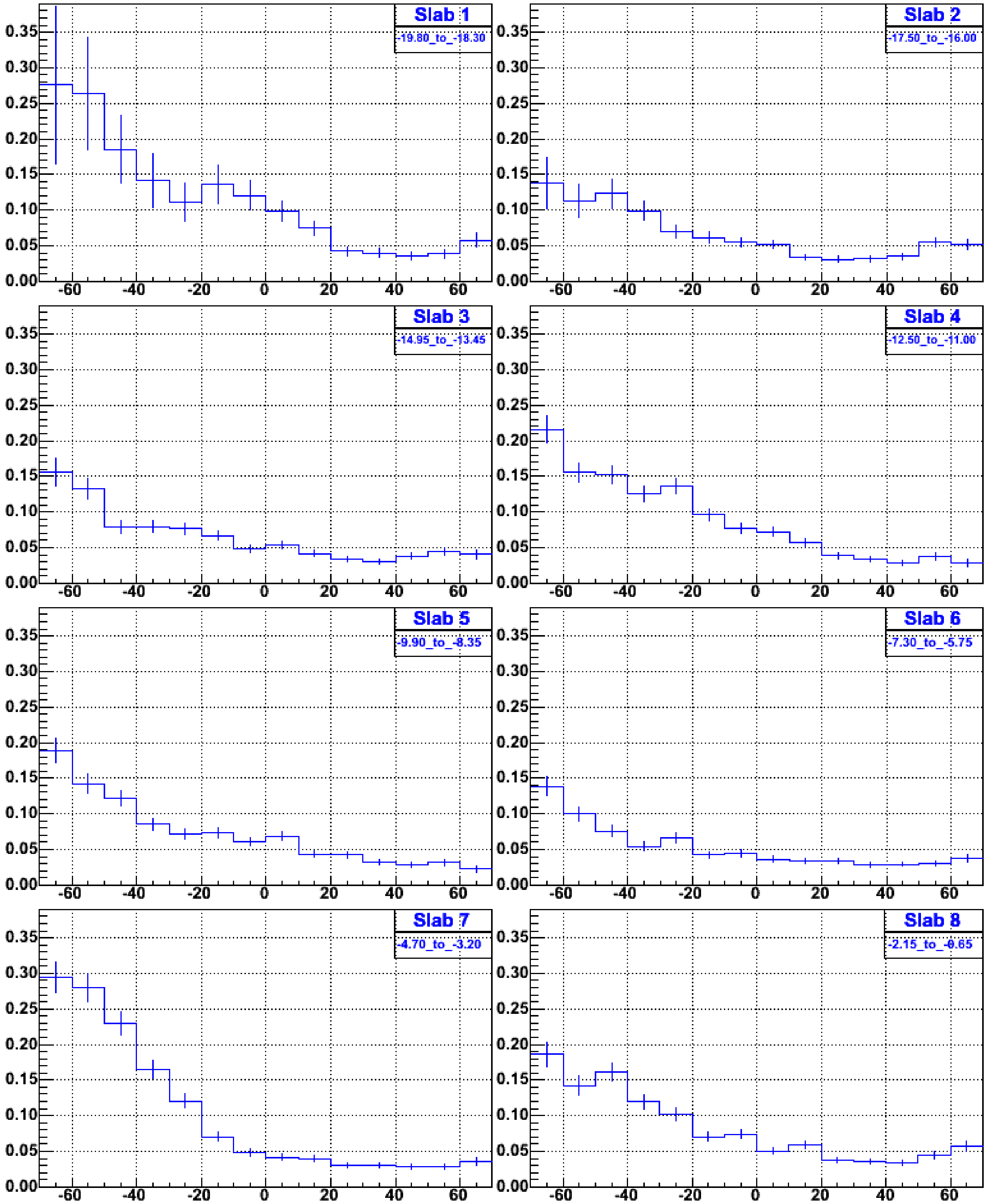

Figure 4: Longitudinal inefficiency of slabs 1 to 8 in the right arm of HH. Horizontal axis is the y coordinate of the system

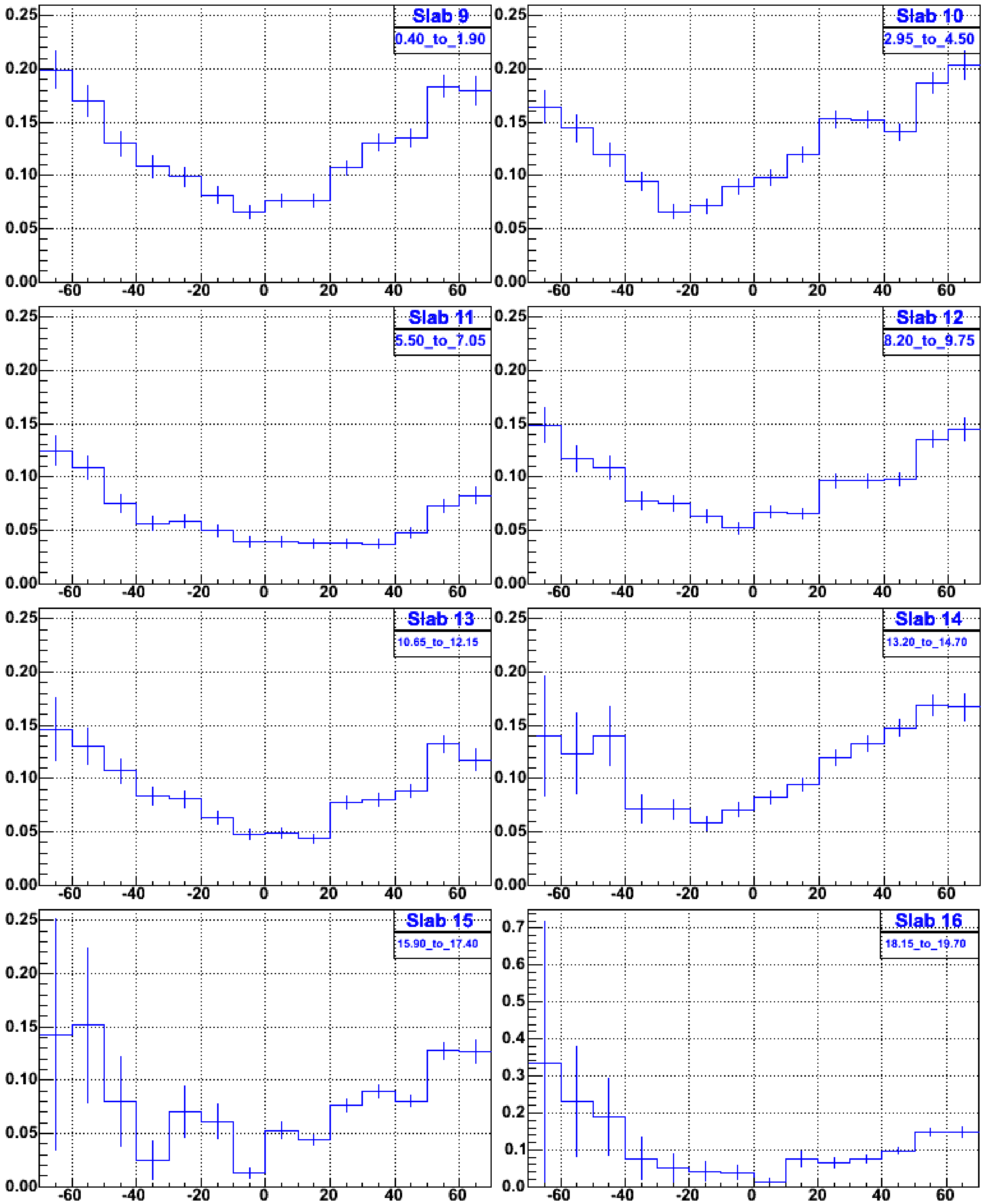

Figure 5: Longitudinal inefficiency of slabs 9 to 16 in the right arm of HH. Please note, that the inefficiency of slab 16 is in a different scale

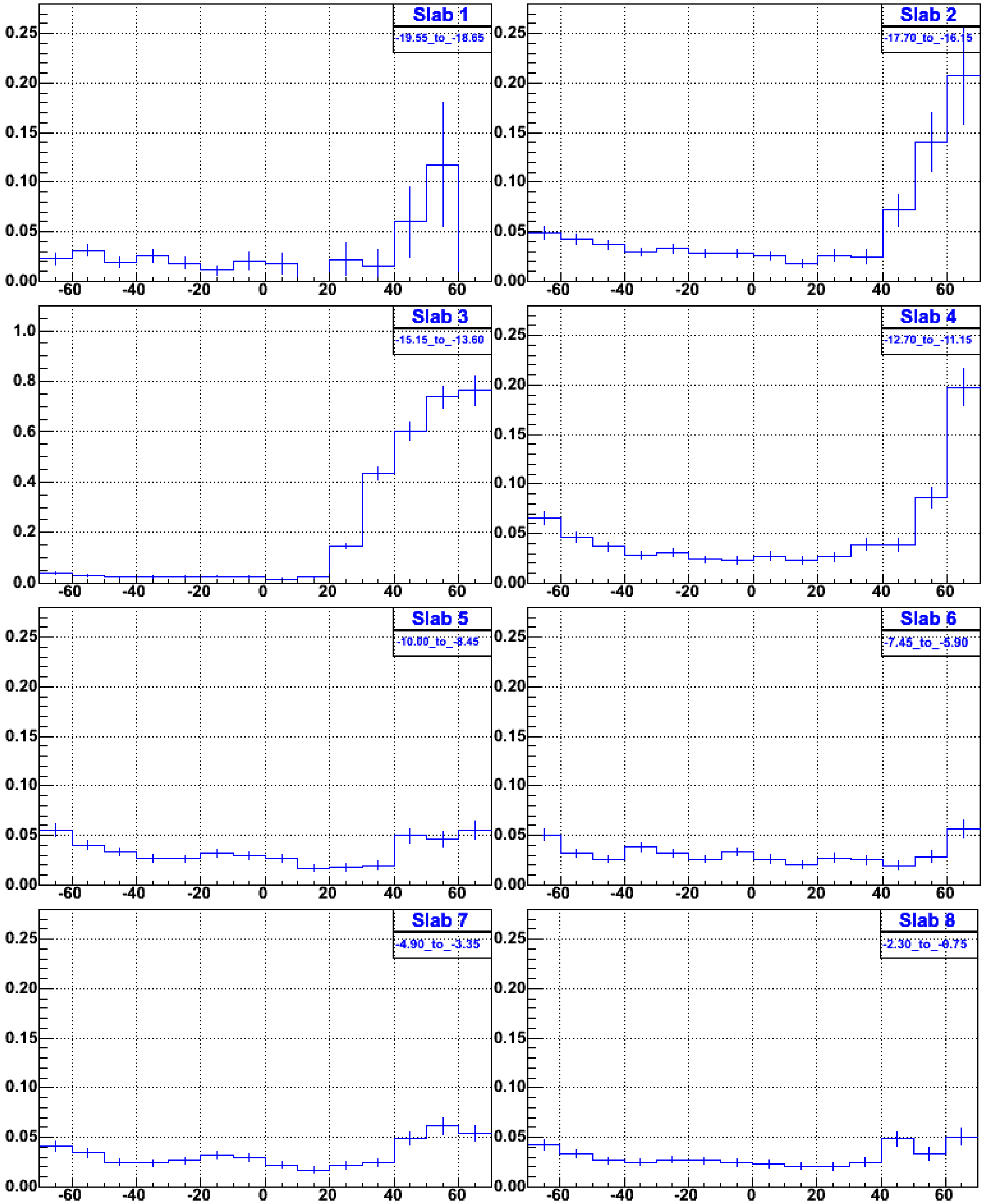

Figure 6: Longitudinal inefficiency of slabs 1 to 8 in the left arm of HH. Please note, that the inefficiency of slab 3 is in a different scale

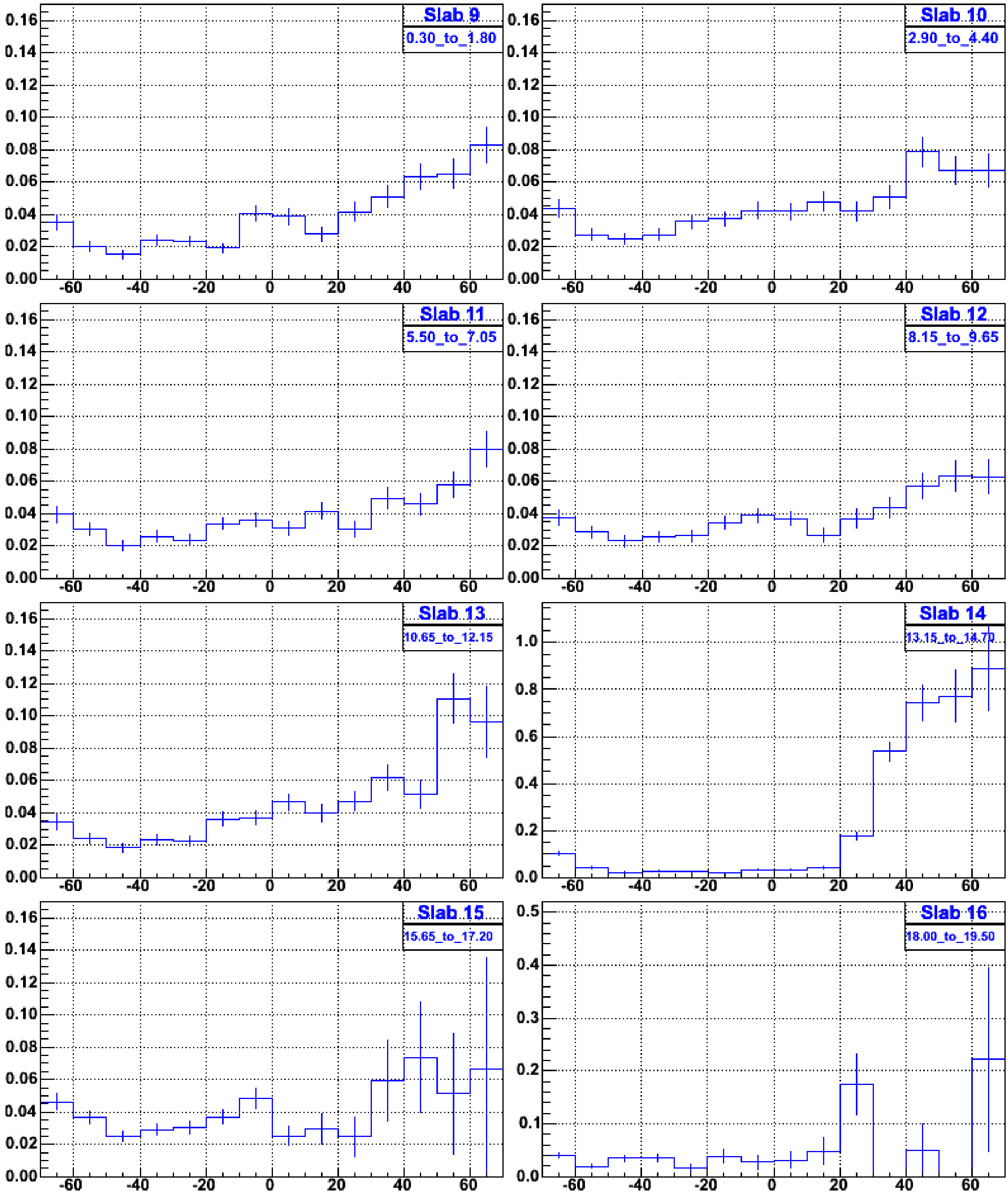

Figure 7: Longitudinal inefficiency of slabs 9 to 16 in the left arm of HH. Please note, that the inefficiency of slabs 14 and 16 are in a different scale

References

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